# MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CORNELL UNIVERSITY.

COMMUNICATED BY E. B. TITCHENER.

## XVIII. FLUCTUATION OF THE ATTENTION TO MUSICAL TONES.

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In the *Anzeiger der Akademie der Wissenschaften in Krakau*, November, 1898, appeared an abstract of a paper by Dr. W. Heinrich, entitled *Zur Erklärung der Intensitätsschwankungen eben merklicher optischer und akustischer Eindrücke.* In the course of this abstract, Dr. Heinrich mentions, as a "ganz unerwartetes Resultat" of his experimental investigation, that minimal tones do not fluctuate ("dass bei Tönen keine Intensitätsschwankungen zu beobachten waren:" p. 374). Trial was made of the high tones of a Galton whistle, and of tones from the middle and lower regions of the scale given by organ-pipes and wide glass tubes. Dr. Heinrich himself was the sole observer (p. 373).

It is with this "wholly unexpected result," and not with any other of Dr. Heinrich's facts or hypotheses, that we are concerned in the present Study. The result seemed to need confirmation, for two reasons. In the first place, experiments upon the fluctuation of attention are regularly carried out in the drill-course in laboratory psychology (junior year) at Cornell University. The instrument employed during the past three years has been, not the watch, but Politzer's acoumeter (as supplied by Meyrowitz). The acoumeter gives a 'ting' or chirping tone which is said to be that of the $c^2$; we have not verified the pitch of our instrument.[1] At any rate, it gives a tone; and this tone has never refused to fluctuate. Secondly, Eckener had used as stimuli, in work upon the fluctuations of attention, (1) the fall of a fine stream of sand upon a vibrating steel tongue, which (as he says expressly) "einen hellen, singenden Ton erzeugte," and (2) the buzz of the Wagner ham-

[1] See the description in A. Politzer, *Lehrbuch der Ohrenheilkunde*, 3d ed., 1893, p. 108. S. Rowe, in *The Physical Nature of the Child*, 1899, p. 27, speaks of the acoumeter as giving a "tap on wood." We are not familiar with this form of the apparatus.

mer of an induction-coil, which must also have had a distinctly tonal character. Fluctuation occurred with both stimuli.[1]

In view of this discrepancy it seemed worth while to make a fairly extended series of experiments upon the question.

(1) *Sample of Results Obtained with the Politzer Acoumeter.*— We may preface the account of these new experiments by citing the results of two series taken with the acoumeter. The instrument is kept tinging at as constant a rate as possible (about 4 tones to the 1 sec.); the observer indicates disappearance and reappearance of the sound by finger movements; a third person, seated with a stop-watch (fifths of seconds) before him, well beyond the range of the observer's hearing, takes the time record.

TABLE I.

*Stimulus: acoumeter. Duration of expt.: approx. 1 min. Interval between expts.: 2 min.*

| OBSERVER. | NO. OF FLUCTUATIONS. | AV. TIME HEARD (SECS). | M. V. | AV. TIME LAPSED (SECS). | M. V. |
|---|---|---|---|---|---|
| C. A. P. | 50 | 9.8 | 4.2 | 4.8 | 1.8 |
| J. H. W. | 25 | 11.2 | 4.5 | 4.4 | .7 |

The observers of this Table had both had more than the usual amount of practice in drill-work. The times are, of course, worthless, as absolute values; the point of the experiment lay elsewhere. But they were obtained under good acoustic conditions, and with all the carefulness that the rough method allowed.

A control series, taken with the two observers simultaneously, gave, as it happened, no single case of coincidence of finger-signals. The cause of the fluctuation could not reside, therefore, in objective changes in the intensity of the stimulus.

(2) *Experiments with Tuning-fork Tone.* An electro-magnetic fork of 1024 v. s. (Koenig) was connected through a suitable resistance to a storage battery. The current was set, roughly, at the strength required just to keep the fork in constant vibration. The fork and its resonator were covered by a large wooden box, and this again muffled in several thicknesses of cloth. The observer was placed in a corridor of the laboratory in a straight line with the sounding fork, and at a distance of 20 to 40 m., as circumstances demanded. Behind the fork, in a different room, a Ludwig kymograph was set up. A Jacquet chronometer wrote fifths of seconds on the drum, and an ordinary electro-magnetic time-marker, connected to a noiseless key under the observer's hand, recorded the fluctuations of attention. The noise of the clockwork was wholly

[1] *Untersuchungen über die Schwankungen der Auffassung minimaler Reize.* In Wundt's *Philosophische Studien*, VIII, pp. 358, 359.

inaudible to the observer. The muffled fork gave out a thin constant tone.

The position of the limen was first determined. Then the experimenter started fork, drum and chronometer, and signalled by a bell-stroke to the observer that an experiment had begun. The observer gave a short signal when he first heard the tone; then left the key-circuit open as long as he continued to hear it; closed the key when it disappeared; held the circuit closed until reappearance; and so on. A complete experiment lasted from 1.5-2 min.; but noises, inside or outside the building, frequently curtailed the periods. All work was done late at night or very early in the morning. No experimental series was carried to the fatigue-point.

A pause of 2-3 min. was allowed between experiment and experiment. During this interval the observer prepared his introspective record. All fluctuation-times were thrown out in which the moment of change coincided with an objective (sound in building, etc.) or subjective disturbance (coughing, need of changing position in chair, etc.). A few very short times were marked 'uncertain' by the observer: these were also discarded. Eckener's distinction of 'objective' and 'subjective' fluctuations came out clearly;[1] the objective were comparatively few in number, and all under 3 sec. duration. They were discarded for introspective reasons similar to those given by Eckener's observers. No time whatever was thrown out by the experimenter; the observer was sole judge. It fortunately never happened that there was any discrepancy between a drum-record and the introspective reconstruction of the experiment by the observer. Had there been, it was our intention to discard the whole experiment. Introspection was the one criterion of correctness.

The observers were Dr. J. O. Quantz (Q), and Messrs. W. C. Bagley (B), C. A. Perry (P), and J. H. Wilson (W). All fully understood the problem in hand, and were cognizant of psychological methods. The listening ear was turned directly towards the source of sound. B, Q and W closed the other ear with cotton-wool; P found this irritating, and therefore left the second ear open. The Table on the following page gives a summary of results.

Two control-series were made with two observers simultaneously, the fluctuation-curves being recorded by time-markers accurately adjusted to write together. Five experiments were taken with P and W: P gave 41, W 26 (subjective and objective) fluctuations. Four were taken with B and W: B gave 29, and W 33 fluctuations. The kymograph tracings

[1] *Op. cit.*, pp. 361 f.

TABLE II.

*Stimulus : fork. Duration of expt.: 1.5-2 min. Total number of fluctuations for each observer: 100. Interval between expts.: 2-3 min.*

| OBS. | DIST. FROM FORK IN M. | AV. TIME HEARD (SECS). | M. V. | AV. TIME LAPSED (SECS). | M. V. |
|---|---|---|---|---|---|
| B | 20-31 | 8.61 | 3.3 | 5.26 | 1.5 |
| P | 29-37 | 8.49 | 2.6 | 4.95 | 1.1 |
| Q | 31-37 | 9.10 | 2.9 | 5.51 | 1.4 |
| W | 23-38 | 7.87 | 2.4 | 5.41 | 1.5 |

show conclusively the general disparity of the two sets of fluctuations in each case. Coincidences are very occasional; and, even when they occur, are not always coincidences of subjective fluctuation. Hence there is no reason to doubt the conviction of observers and experimenter, that the fork did not vary in objective intensity during an experimental sitting.

(3) *Experiments with Tone of Blown Bottle.* Although the fact that tones fluctuate seemed to be fairly well proved by the foregoing experiments, we thought it well to test the matter further with other sources of sound. We began with one of the bottles of the Stern apparatus for continuous tone-change. The bottle gave, approximately, the $c^1$ of 256 vibrations. It was sounded steadily by a stream of air from the compressed-air tank belonging to the apparatus. It was covered by a wooden box, large enough not to interfere with the sounding of the tone; the box was muffled in cloth, as before.

We need cite only a single series: duration of expt. 1 min.

| OBS. | NO. OF EXPTS. | AV. TIME HEARD. | M. V. | AV. TIME LAPSED. | M. V. |
|---|---|---|---|---|---|
| P | 20 | 9.0″ | 2.4″ | 5.4″ | 1.9″ |

Similar results were obtained from P in other series, and also from a number of series with the observer W. A series of 10 expts. taken with P and W simultaneously showed the usual disparity, guaranteeing the objective steadiness of the bottle-tone.

We next made a few trials with the Galton whistle,—another of Dr. Heinrich's tone-sources. But, although we had about 45 m. of corridor at our disposal, we found it impossible, by any amount of muffling and door-closing, to get a satisfactory limen.[1] There were a few indications of fluctuation; but we can say nothing definite upon the matter. The squeaking chirp of the whistle is, however, so like the chirp of the acoumeter that there can be little doubt that the fluctuation would occur under the right acoustic conditions.

[1] These experiments were made so near the end of the academic year that we had no time to have a special 'soundless box' constructed, to take the instrument; we were forced to be content with the means of screening and muffling available at the moment. Next year we hope to be able to settle the issue finally, as regards the Galton whistle.

The question now arises: If tones fluctuate, as we have found them to do, how is it that so careful and practised an observer as Dr. Heinrich has been led to make a contrary statement? It is difficult to offer any suggestion. It is possible—despite the statement that the tone "auf der äussersten Grenze der Hörbarkeit" was "immer continuierlich und constant"—that Dr. Heinrich did not secure really liminal tone-intensities. It must be remembered that he was his own sole observer, so that an intercomparison of liminal distances was impossible. We found it an exceedingly nice matter, and one that called for a considerable degree of practice on the part of the observer, to determine the place of just-audible tone intensity. Our final method was to let the observer move to and fro until he thought he had found the limen; then to have him listen attentively for some 20 or 30 seconds; and then, if the tone was continuously audible (as generally happened), to push him out, little by little, until the real intensity-limen was obtained. Tones have a surprising carrying-power; and they are so sharply differentiated from the background of faint noise, against which they stand out, that the attention fastens to them easily and persistently.

There are, of course, other and considerable difficulties in the work. But Dr. Heinrich is probably as well aware of them as we are. He says explicitly: "Die Schwierigkeiten in der Beobachtung der Intensitätsschwankungen sind so erheblich, dass man immer längerer Uebung bedarf, um sie genauer verfolgen zu können" (p. 373). We need not enumerate these difficulties: we found nothing in any of them, whether technical or introspective, that could account for the divergence of results as plausibly as the suggestion thrown out above. We hope that Dr. Heinrich may be incited by our results to repeat his experiments upon a number of observers.

## SUMMARY.

We have found, in opposition to the statement made by Dr. Heinrich, that tones of liminal intensity, attentively followed by practised observers, evince the fluctuations ordinarily described as 'fluctuations of attention.' This rule holds of discrete (Politzer's acoumeter) and of continuous tones (tuning-fork, blown bottle). We were unable, under our laboratory conditions, to obtain a tone of the required minimal intensity from the Galton whistle.